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EVIDENCE FOR A STRICTLY SENTENCE-INTERNAL ANTECEDENT-FINDING MECHANISM

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Previous research has demonstrated that there is a process by which the pronoun they can exert an influence on the syntactic analysis of a following ambiguous expression of the form of flying planes. In several experiments subjects have been presented with recordings of sentence fragments such as (1).

- (1) (a) As the birds soar gracefully over the field, flying kites...
- (b) As they soar gracefully over the field, flying kites...

Immediately at the end of each such fragment, the subject is presented with a visual target word; this is always is in the critical cases. The subject's task is simply to read the verb aloud as rapidly as possible. The results show that the speed of this response is sensitive to the form of the subject of the initial subordinate clause. The response takes anywhere from 20 to 50 milliseconds longer when the clause subject is the pronoun they rather than a lexical NP or you.

Apparently, the presence of they sets up a search for an antecedent. This in turn leads the subject to prefer the plural noun phrase reading of the ambiguous expression because this expression provides a potential antecedent if it is construed in this way. This effect can be called the Pronoun Bias Effect. Note that the effect consists in a slowing of responses to is when they appears in prior context. For expository convenience, we can call the mechanism that implements the coreference relation implicated in this effect the Structural Reference Process.

Interestingly, the Pronoun Bias Effect goes through even when the coreference relation involved is odd. Thus the effect seems to work as well with examples like (2b) as it does with cases where the coreference relation produces a more reasonable interpretation, as in (2a) or (1).

- (2) (a) If they use a lot of oil, frying eggs...
- (b) If they eat a lot of oil, frying eggs...

These results, which have been replicated, strongly suggest that the Structural Reference Process lacks

access to much semantic and pragmatic information that is ultimately relevant to antecedent selection. It seems likely, for example, that most speakers will readily reject the NP the kitchen smells in example (3) as the antecedent of they.

- (3) Once they've eaten their fill, the kitchen smells no longer bother the hungry prisoners.

See Cowart (1983) and Cowart and Cairns (1986) for experimental results and discussion.

An important further observation is that the Pronoun Bias Effect does not arise where there is a syntactic impediment to the coreference relation, as in cases such as (4).

- (4) Just because they frequently require that boiling vegetables...

However, the original experimental demonstration of this phenomenon was flawed by the fact that several of the items seemed to show a strong inherent bias against the target verb is. That is, subjects seemed to be strongly biased against the verb form is, relative to are, even in the control condition where you was the subject of the initial subordinate clause. To correct for this a reanalysis was done which excluded the five items with the most extreme bias. With this more balanced set of experimental sentences, there was still no evidence that the Pronoun Bias Effect could operate when the ambiguous expression is embedded within a complement clause. This result may seem intuitively obvious, but as will be evident shortly, not every intuitively obvious property of the Pronoun Bias Effect is real.

At this point there is evidence that the Pronoun Bias Effect can be suppressed when the candidate antecedent for they is placed in a syntactically ineligible position, but that when the coreference relation it involves yields an odd interpretation and there is no syntactic impediment to coreference, the effect appears.

Recent proposals by Fodor (1983) provide a particularly interesting framework within which to view the phenomena reviewed above. Fodor proposes that some subset of human linguistic abilities is realized by a cognitive module that, among other properties, is "informationally encapsulated." The experimental results outlined above seem to provide support for Fodor's views in that the procedures that implement the Pronoun Bias Effect seem to be informationally

encapsulated; they are unable to deploy all of the listener's relevant knowledge.

One view of the results to date leads to the suggestion that the Structural Reference Process is defined over a syntactic representation of the incoming sentence. Such a representation would both provide the information necessary to determine which NPs were and were not structurally eligible and would presumably exclude the semantic and pragmatic information that is apparently not relevant to the pronoun effect. In order to test this suggestion, the work to be reported here will assess the scope of the Pronoun Bias Effect, that is, how much of prior context is relevant to coreference assignments made by the Structural Reference Process. Given the elementary observation that discourse relations seem able to span far larger portions of an utterance than syntactic relations, information on the scope of the Pronoun Bias Effect may reflect on the character of the utterance representation it uses. If the effect is sensitive to the content of a preceding sentence, this will suggest that the Structural Reference Process is either another manifestation of general discourse processing mechanisms or at least a system that interacts closely with them. If it is not sensitive to antecedents in preceding sentences, then this will tend to affiliate the process with syntactic processes, which seem to have the sentence as their maximal domain. To put it another way, a reasonable tentative distinction between discourse processing systems and syntactic or structural processing systems assumes that the discourse systems have access to a representation normally including some multi-sentence span of the incoming utterance while syntactic or structural processing systems operate on representations incorporating material from only a single sentence.

Experiment 1

Two recent experiments have been done with materials similar to those in (5) in the interest of finding out what relation there is between the Pronoun Bias Effect and a preceding sentence. Each item consists of a short context sentence followed by a sentence fragment structured like those used in earlier experiments.

Materials: The materials in (5a,b) should provide a replication of the Pronoun Bias Effect. Item (5c) provides a preceding antecedent for they that should interfere with this effect if the Structural Reference Process has access to context outside the current sentence.

- (5) (a) **Miller** might simply be boosting morale. Although **these coaches** imply that few schools can maintain a long winning streak, losing games...
- (b) **Miller** might simply be boosting morale. Although **they** imply that few schools can maintain a long winning streak, losing games...
- (c) **These coaches** might simply be boosting morale. Although **they** imply that few schools can maintain a long winning streak, losing games...

The target item was always is. There were also filler items having different structures.

Design: The experimental design involves one within-subjects repeated measures factor, Context, with three levels (no they and no antecedent, they present without discourse antecedent, they present with discourse antecedent). There is also a between-subjects Groups factor that reflects the three materials conditions that result from using each materials item in each of the three conditions.

Procedure: Experiment 1 was a paper and pencil judgement task administered in classroom settings. Judges were presented with a mimeographed list of sentence fragments such as those in (5). Responses were collected from 100 judges. No judge saw more than one version of a given item and each individual saw ten items in each of the experimental conditions. The items were pseudorandomly ordered and the experimental cases were mingled with 30 filler items. Each item included a sentence and a sentence fragment. The task was to indicate whether IS or ARE seemed to be the better continuation for each item. This response was recorded on a machine-readable answer sheet.

Results: The results were clear-cut and surprising (see Table 1). The first two conditions produced a straightforward replication of the Pronoun Bias Effect. IS and ARE were selected equally often when the fragment included no pronoun, while preference for IS

Table 1: Experiment 1, percent of subjects selecting is as verb following the ambiguous expression

Condition	Percent
No Pronoun Present (a)	50
<u>They</u> Present, No Prior Antecedent (b)	43
<u>They</u> Present, With Prior Antecedent (c)	42

declined to 43% when they was present. In the critical third condition, preference for IS was at 42%. That is to say, the Pronoun Bias Effect was as much in evidence with a candidate antecedent ahead of the sentence fragment as without it. The Context effect was significant ($F(2,58)=7.47$, $p<.005$) and there was obviously no significant difference between the second and third conditions. On this evidence it appears that the Structural Reference Process lacks access to discourse context.

Discussion: This outcome was quite unexpected. Because the Pronoun Bias Effect so clearly involves a reference relation, it was expected that this study would demonstrate clear sensitivity to prior context. The fact that this result emerged in a paper and pencil task is doubly surprising because there was ample time for subjects to consider the relevance of prior context and the antecedent it contained (in the critical condition). The fact that the Pronoun Bias Effect persisted suggests that the effect is implemented by some device with access only to the current sentence.

However, with respect to the issues under consideration here, the materials for Experiment 1 had one important limitation. In about half the items it was possible to construe the subject of the first sentence, the instance of they, and the ambiguous expression as all referring to the same entities. This reflected the fact that a somewhat different question had guided the original construction of the materials. Nevertheless, it is obviously only cases where this three-way relation is not available that can bear on the question whether some sentence-internal mechanism produces the Pronoun Bias Effect.

This matter was first addressed by isolating those items from Experiment 1 where the three-way coreference relation was not available (as in (5c)). These 13 cases show essentially the same pattern as the experiment as a whole, though the Pronoun Bias Effect was marginally weaker. Preference for the verb form is declined from 49% to 43% across Conditions A and C, related to (5a) and (5c) above.

Experiment 2

Experiment 2 addressed this matter directly; the materials for Experiment 1 were revised such that they could take either the subject of the first sentence or the ambiguous expression at the end of the fragment as its antecedent, but those two potential antecedents could not be coreferential. Otherwise, the materials, experimental design, and the procedure were those of

Experiment 1. Seventy-six Ohio State University undergraduates participated as judges.

The results are shown in Table 2. It is evident that the Pronoun Bias Effect is a little weaker in

Table 2: Experiment 2, percent of subjects selecting is as verb following the ambiguous expression

Condition -----	Percent
No Pronoun Present (a)	51
<u>They</u> Present, No Prior Antecedent (b)	44
<u>They</u> Present, With Prior Antecedent (c)	45

Condition C here than in Experiment 1, but the pattern essentially holds. This appearance is borne out by the statistical analysis. An analysis of variance shows that the Context effect is significant ($F(2,58)=3.34$, $p<.05$). A t-test on the contrast between the first and third conditions shows a significant difference ($t(29)=1.95$, $p<.05$, one-tail).

Thus, the Pronoun Bias Effect seems to operate in this task about as reliably when an antecedent for they is available in the preceding sentence as when it is not.

The next issue to address obviously is the question whether similar effects arise in a reaction-time task. One possible interpretation of the results of Experiments 1 and 2 suggests that they derive in some way from a strategy peculiar to reading. Though previous results with the Pronoun Bias Effect have been obtained with auditory as well as written presentations of materials, the best way to determine the importance of this suggestion is to replicate the experiment reviewed above with auditory presentations.

A pilot version of this experiment (with no counterbalancing of materials) produced equivocal results. This test used the materials, and design outlined above for Experiment 1 except that there was no counterbalancing of materials across experimental conditions. In statistical terms, materials were nested under experimental treatments. Ten subjects participated.

As in previous experiments, the presence of they slowed reaction-time to is in Condition B relative to Condition A. This contrast (of 440 vs. 458 msec.) is significant at the .05 level ($t\text{-pair}(9)=2.65$). While there was a trend in this same direction in the third condition as well (440 vs. 448 msec.), this effect was not significant ($t\text{-pair}(9)=1.60$). Since materials were nested under experimental conditions in this pilot, these results will support no strong conclusions

in any direction. A fully counterbalanced version of this experiment is in progress.

One other possible confounding factor bears some consideration. Though subjects in the paper and pencil task of Experiments 1 and 2 were under no particular time pressure, it is possible that they nonetheless drift toward a strategy in which they essentially ignore the context sentence of each item. Obviously, the potential antecedent in the context sentence will have no effect if the sentence isn't read. This suggestion predicts, of course, that results obtained with items at different serial positions in the materials lists will obtain different results. In this connection, a further analysis made a rough comparison of the results obtained on Experiment 2 with the first six items versus the last six, and with items on the first half of the list versus items on the second half. In both cases it appears that the results are essentially the same for those items occurring early on the list and late on the list.

It seems fair to say that, while the empirical question has hardly been settled definitively, there is important evidence suggesting that the Pronoun Bias Effect arises independently of the content of the sentence preceding the one bearing they.

Discussion

The several results of the experimental program reviewed above endorse or at least suggest some theoretically important conclusions. First, the Pronoun Bias Effect exists; the presence of a pronoun in prior context can influence the syntactic analysis assigned to a following structurally ambiguous constituent. Second, while a coreference relation seems to be implicated in the Pronoun Bias Effect, the Pronoun Bias Effect is not sensitive to selectional or pragmatic influences that are otherwise commonly involved in matters of reference. Rather, the coreference relation seems to be assigned even when the resulting interpretation is strange. Third, the Pronoun Bias Effect seems to be affected by the structure of the sentence bearing they. Apparently, the coreference relation is assigned only when the antecedent is in a structurally eligible position. Fourth, the mechanism that produces the effect seems to have no access to the content of the preceding sentence.

It may be useful to review a model which can accommodate these findings. The model is built on two principal claims: 1) there are two distinct types of

processes, structurally-oriented processes and interpretively-oriented processes, involved in comprehending reference relations, and 2) information flows from structurally-oriented processes to interpretively-oriented processes. This is a logical claim not a temporal one; it says nothing about when each process begins to work on incoming material.

The processes can be differentiated by reference to three criteria: 1) the character of the representation of the incoming utterance to which each process has access, 2) the way that pronouns are differentiated, and 3) the character of the relations the processes establish. Structural reference processes are defined, by hypothesis, over a representation that expresses the kinds of properties and relations captured by some form of phrase marker. That is, precedence and dominance relations, lexical content, grammatical categories, etc. Discourse reference processes, by contrast, are assumed to be defined over interpretations; representations that explicitly capture the semantic, pragmatic and other interpretive properties and relations ascribed to the entities referenced in the utterance. In particular, these representations are assumed to be constructed with reference to whatever non-linguistic knowledge the listener may have about the entities, relations, processes, etc. mentioned in a given discourse.

Structural reference processes, by hypothesis, differentiate pronouns only according to morphological parameters such as case, gender and number, while discourse reference processes treat referring expressions differently according to the semantic environments in which they occur. Relations established by discourse reference processes are integrative; properties ascribed to one member of a pair of coreferential expressions can, for example, be extended to the other. The relations established by structural reference processes are simple ones of linking or pointing.

In this framework, the Structural Reference Process is a syntactic process in the sense that it is defined over a syntactic representation. This model allows a coreference relation assigned by the Structural Reference Process to interact with the processes that select a syntactic analysis for ambiguous expressions used in the experiments reported above; they communicate because they are defined over the same kinds of representation.

Though this model provides a reasonably parsimonious account of the results available to date, it also makes a number of predictions that go well beyond the results

reviewed above. Most simply, it predicts that effects related to the Pronoun Bias Effect can be obtained with other pronouns. Furthermore, the mechanisms and representations suggested should be as relevant to ordinary anaphoric relations as to the cataphoric ("backwards anaphora") cases implicated in the Pronoun Bias Effect. It suggests that other structural properties of sentences may influence the Pronoun Bias Effect, e.g., the contrast between subordinate and coordinate structures may be significant even though, for example, they in the second clause of a two-clause sentence can easily take an antecedent in the first clause whichever sort of relation obtains between the clauses. These and other implications of the model are under investigation.

It has been suggested that there may be a way to avoid the proposal that there are two different kinds of process involved in assigning reference relations. On this account there would be a single reference-assigning mechanism responsible for intrasentential cases related to the Pronoun Bias Effect as well as intersentential cases involving the same pronouns. However, according to this alternative view, some kinds of information take longer to process than others, and this leads to the illusion that those kinds of information are not available at certain stages of processing. Thus, it may be that a single processing sub-system deals with both the syntactic and the semantic/pragmatic factors that bear on the selection of antecedents for they, but the latter factors become effective later because of the additional processing demands they impose. Similarly, establishing a reference relation outside the current sentence might be more time-consuming or demanding than establishing one within the current sentence. Clearly a convincing proposal along these lines will have to provide some principled account of the extra processing demands related to semantic/pragmatic processing or accessing the content of earlier sentences in the discourse.

For the moment it is worth noting that there are two kinds of evidence that count against this suggestion. First, much of the evidence that semantic/pragmatic factors do not affect the Pronoun Bias Effect comes from cases where the source of the oddity is traceable to a selection restriction associated with the verb of the initial subordinate clause bearing they. Thus in (2b) above note that the oddity of the fragment arises from the fact that eat requires an animate subject. It is not clear why it should take longer to compute the consequences of this selection restriction than to determine, say, that a given NP is in a syntactically

ineligible position. Secondly, the interval between the appearance of they and the ambiguous expression in cases like (5) is quite long. There seems to be ample time to determine whether a discourse antecedent is available before the ambiguous expression appears.

In brief, the results of the research program outlined above provide substantial evidence for the suggestion that reference relations are assigned in language processing by two distinct subsystems, one of which is markedly structural in character and deals with relations only within a single sentence. The apparent inability of this system to access some information that is clearly ultimately relevant to the reference relations it assigns suggests that it is an informationally encapsulated cognitive module in the sense of Fodor (1983).

NOTES

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